COMPRESSOR HAVING SWASH PLATE ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The subject invention relates to a refrigerant compressor and, more particularly, to a swash plate type compressor, with a variable displacement mechanism suitable for use in an automotive air conditioning system.

2. Description of the Prior Art

[0002] A typical automotive air conditioning system used in a modern automotive industry is designed to cool, dehumidify, clean, and circulate the air in a vehicle. The typical air conditioning system presents a closed, pressurized system includes basic components such as, for example, a compressor, a condenser, a receiver/dryer or accumulator, an expansion valve or orifice tube and a plurality of additional components used in combination therewith to increase efficiency and dependability of the air conditioning system.

[0003] The compressor is a heart of the automotive air conditioning system and is designed to separate high-pressure and low-pressure sides of the air conditioning system and includes outlet and inlet portions. The primary purpose of the compressor is to draw the low-pressure and low-temperature vapor from the evaporator and compress this vapor into high-temperature, high-pressure vapor. The secondary purpose of the compressor is to circulate or pump a refrigerant through the air conditioning system under the different pressures required for proper operation of the air conditioning system. The compressor is located in an engine compartment and is driven by the engine's crankshaft via a drive belt.

[0004] The modern automotive industry includes numerous types of compressors. The types include a piston compressor, a rotary vane compressor, and a scroll-type compressors. The piston compressor includes pistons arranged in an in-line, axial, or radial designs. The pistons are engaged in cylinders, respectively, and designed to have an intake stroke and a compression stroke for each cylinder. The common variation of the piston type compressor is a variable displacement compressor,

wherein the pistons are connected to a swash plate. The angle of the swash plate determines the stroke of the pistons and is controlled by the difference in pressure between the outlet and inlet portions of the compressor. When the stroke of the pistons is increased, more refrigerant is being pumped to increase cooling.

[0005] The art is replete with various designs of the variable displacement compressors one of which is a swash plate type compressor with a variable displacement mechanism. Different designs are disclosed in U.S. Patent Nos. 4,428,718 to Skinner, 4,960,366 to Higuchi, 5,056,416 to Ota et al., 5,255,569 to Terauchi et al., 6,416,297 to Kawaguchi et al, and 6,564,695 to Herder et al. Some of the aforementioned patents disclose compressors of various designs that include a housing having a crank chamber and a suction chamber separated by a wall one from the other. These compressors include a spacer integral with or pressed on a drive shaft designed to support a coil spring positioned between the spacer and a slide member of the valve control mechanism wherein the coil spring, supported by the spacer constantly applies a biasing force to a slide member of the valve control mechanism, thereby controlling the inclination of the slant angle between the swash plate and the drive shaft of the valve control mechanism in different operational modes of the compressor.

[0006] There is a constant need in the area of the automotive industry for an improved drive shaft for pneumatic and electronic valve control assemblies to replace a spacer that requires installation equipment to position the spacer annularly about the drive shaft, thereby decreasing material costs of the compressor, and other expenses associated with assembling of the compressor.

BRIEF SUMMARY OF INVENTION

[0007] A compressor of the present invention includes a drive shaft extending along a longitudinal axis A, a swash plate assembly operatively connected to and driven by the drive shaft, and a retainer ring for disposition about the drive shaft. The drive shaft of compressor includes first and second annular grooves therein and spaced longitudinally from one another.

[0008] An advantage of the present invention is to provide a swash plate compressor having a drive shaft that can be used with either pneumatic and electronic compressors.

[0009] Still another advantage of the present invention is to provide the drive shaft for the compressor to replace a spacer that requires installation equipment to position the spacer annularly about the drive shaft, thereby decreasing material costs of the compressor, and other expenses associated with assembling of the compressor.

BRIEF DESCRIPTION OF THE DRAWINGS

[00010] Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[00011] Figure 1 is a fragmentary perspective view of a drive shaft having a drive hub and a journal member disposed annularly about the drive shaft and connected with the drive hub;

[00012] Figure 2 is a cross sectional view of the compressor having the drive shaft and a swash plate assembly installed therein;

[00013] Figure 3 is a cross sectional view of the drive shaft extending through the swash plate assembly;

[00014] Figure 4 is a side view of the drive shaft having a retainer ring disposed annularly about a first groove in the drive shaft to retain a spring disposed around the drive shaft and between the retainer ring and a sleeve of the drive shaft;

[00015] Figure 4A is a partial and enlarged view of the retainer ring disposed annularly about the first groove in the drive shaft;

[00016] Figure 5 is another side view of the drive shaft having the retainer ring disposed annularly in a second groove of the drive shaft;

[00017] Figure 5A is a partial and enlarged view of the first groove defined in the drive shaft;

[00018] Figure 6 is a front view of the retainer ring;

[00019] Figure 7 is a side view of the retainer ring;

[00020] Figure 8 is a side view of the spring; and

[00021] Figure 9 is end view of the spring.

DETAILED DESCRIPTION OF THE INVENTION

[00022] Referring to the Figures 1 through 9, wherein like numerals indicate like or corresponding parts throughout the several views, a compressor is generally shown at

10.

[00023] The compressor 10 includes a drive shaft 12 extending along a longitudinal axis A, a swash plate assembly, generally indicated at 14, operatively connected to and driven by the drive shaft 12, and a retainer ring 22 for disposition about the drive shaft 12. The drive shaft 12 of compressor 10 includes first 16 and second 18 annular grooves therein and spaced longitudinally from one another and a conical ramp, generally indicated at 20, extending out of the first annular groove 16 toward the second annular groove 18 for facilitating movement of the retainer ring 22 out of the first annular groove 16 and along the drive shaft 12 to the second annular groove 18.

[00024] Referring to Figure 2, the compressor 10 includes a central housing 24 having terminal ends 26, 28, and a rear housing 30 connected to the central housing 24 at the terminal end 26 of the central housing 24. The rear housing 30 has an opening and a plurality of holes (not shown) spaced one from the other and extending along the longitudinal axis A from the rear housing 30 to the opening of the rear housing 30. The compressor 10 includes a crank chamber 32 defined within the central housing 24. The compressor 10 further includes a front housing 34 connected to the central housing 24 at the other terminal end 28. The front housing 34 includes a suction chamber 36 and a discharge chamber 35. The compressor includes a suction port (not shown) and a discharge port (not shown) defined in the front housing 34.

[00025] Referring to Figures 1 through 4, the drive shaft 12 of the present invention includes a generally cylindrical configuration and has first and second ends. The drive shaft 12 has a variable diameter 40, as viewed in cross section. The drive shaft 12 is rotatably supported and engaged within the central housing 24 and the rear housing 30 of the compressor 10. The compressor 10 includes first 42 and second 44 needle bearings. The first needle bearing 42 is disposed annularly about the first end of the drive shaft 12 and supported by the rear housing 30. The second needle bearing 44 is disposed annularly about the second end of the drive shaft 12 and supported by the central housing 24 for rotatebly supporting the drive shaft 12 within the compressor 10.

[00026] As appreciated by those skilled in the art, during the operational mode of the compressor 10, the drive shaft 12 is connected to and is rotated by an engine of a vehicle (not shown) through an electromagnetic clutch assembly (not shown) driven by the engine and having an electromagnetic clutch and a belt engaging a pulley on the

electromagnetic clutch.

[00027] The first end of the drive shaft 12 includes a plurality of spline teeth or male connectors 50 integral with and extending outwardly from and longitudinally along the first end of the drive shaft 12 with respect to the longitudinal axis A. The spline teeth 50 of the drive shaft 12 are mechanically engage with complementary tracks or female splines defined within clutch driver (not shown).

[00028] The first 16 and second 18 annular grooves of the drive shaft 12, as best shown in Figure 3, include diameters 56, 58 spaced by parallel sides 60, 62, 64, 66, respectively. The first groove 16 presents the sides 60, 62 extending perpendicularly from the longitudinal axis A, wherein one of the sides 60 extends perpendicularly from the longitudinal axis A to the diameter 40 and the other side 62 presents an intersection between the conical ramp 20 and the diameter 56. The sides 64, 66 of the second annular groove 18 extend perpendicularly from the longitudinal axis A to the diameter 40. Alternatively, the first 16 and second 18 annular grooves may have different diameters with respect to one the other.

[00029] The compressor 10 includes the swash plate assembly 14 having a drive hub 70 connected to the drive shaft 12 and being rotatable with the drive shaft 12 around the longitudinal axis A. The drive hub 70 includes a generally tubular portion, generally indicated 72, surrounding the drive shaft 12 and a counter weight portion 74, extending from the tubular portion 72 to a periphery 76. The drive hub 70 includes a boss 78 at the periphery 76. The boss 78 includes a first pin 79 extending through the boss 78 spaced from and transversely to the drive shaft 12.

[00030] The swash plate assembly 14 includes a sleeve 80 disposed about the drive shaft 12 and axially spaced from the drive hub 70. The swash plate assembly 14 includes a journal member 82 is supported by and connected to the sleeve 80 for tilting movement relative to the longitudinal axis A. The journal member 82 has an extension 84 extending from the journal member 82. The journal member 82 includes a second pin 86 extending through the extension 84. The swash plate assembly 14 includes a hinge link 88 having holes 90, 91 spaced one from another and being complementary to the first 79 and second 86 pins. The hinge link 88 interconnects the first 79 and second 86 pins for rotating the journal member 82 with the drive hub 70 while allowing the journal member 82 to tilt relative to the longitudinal axis A.

[00031] The swash plate assembly 14 includes a swash plate 92 of a generally

circular configuration extending from the journal member 82 to a peripheral edge 94. The swash plate 92 is disposed within the central housing 24. The swash plate 92 is movable forwardly and rearwardly along the longitudinal axis A in a sinusoidal motion, being inclined with respect to the longitudinal axis A to diverge from a perpendicular position to an angular position with respect to the longitudinal axis A in different modes of operation of the compressor 10.

[00032] The modern automotive art includes numerous compressor designs having an electronic mechanism design for operation of the compressor 10 and a pneumatic mechanism design, as shown in Figure 3. The compressor 10 having the electronic mechanism includes first 94 and second 96 coil springs. The first coil spring 94 is disposed annularly about the drive shaft 12 and between the drive hub 70 and the sleeve 80. The first coil spring 94 urges the swash plate 92 toward the front housing 34, i.e., in the direction in which the inclination angle of the swash plate 92 decreases. The second coil spring 96 is disposed annularly about the drive shaft 12 and is positioned between the sleeve 80 and the retainer ring 22 disposed in the first annular groove 16. When the swash plate 92 is positioned at the maximum inclination angle, as best shown in Figure 2, the second coil spring 96 does not apply a biasing force to the swash plate 92. When the swash plate 92 is shifted to the minimum inclination angle position, the second coil spring 96 is compressed between the sleeve 80 and the retainer ring 22. Further, the second coil spring 96 urges the swash plate 92 away from the front housing 34, i.e., the direction that the inclination angle of the swash plate 92 increases from the retainer ring 22. The pneumatically operated compressor 10 of the present invention includes only one coil or spring, i.e. the first coil spring 94, disposed annularly about the drive shaft 12 and between the drive hub 70 and the sleeve 80. The retainer ring 22 is disposed within the second groove 18 to control the stroke of the swash plate assembly 14 during the operation of the compressor 10. With respect to different designs of the compressor 10 the retainer ring 22, disposed about the drive shaft 12, is slided along the conical ramp 20 from the first annular groove 16 to the second annular groove 18.

[00033] The swash plate assembly 14 includes at least one piston 100 coupled to the swash plate 92 for reciprocating in the central housing 24 upon movement of the swash plate 92. While either a wobble plate or swash plate configuration may be employed, both being well known to those skilled in the art, only the swash plate 92

configuration shall be described further. Figure 2 illustrates the swash plate 92 configuration utilizing the pistons 100 (only one is shown) to compress a refrigerant. The piston 100, slidably moveable within a first cylinder bore, i.e. compression chamber 102 (only one is shown) for compressing the refrigerant in the compressor 10. The compression chambers 102 are formed in the central housing 24 and the pistons 100 are accommodated in each compression chamber 102 and coupled to the swash plate 92 through a corresponding shoe 104. The compressor 10 further defines a second compression chamber (not shown) spaced apart from the first compression chamber 102 for receiving the refrigerant from the suction chamber 36 in the same manner as the first compression chamber 102. A cylinder wall of the compressor 10 separates the first compression chamber 102 and the second compression chamber. A second piston (not shown) is positioned in the second compression chamber and is slidably moveable therein for compressing the fluid in the compressor 10.

[00034] In the preferred embodiment, the compressor 10 includes seven pistons and seven compression chambers, however, for simplicity, only one piston 100 and the first compression chambers 102 are discussed. Hence, the number of pistons 100 used in the compressor 10 is not intended to limit the present invention. The crank chamber 32 is used to supply the oil to the pistons 100 to minimize friction along the cylinder wall of each compression chamber 102. The oil that is stored in the crank chamber 32 is also used to lubricate other moving parts in the compressor 10.

[00035] When the compressor 10 is in operation in the preferred embodiment, the pistons 100 are reciprocated or slidably moved within their respective compression chambers 102. A suction reed (not shown) is moved to the suction position as the piston 100 moves from a top dead center position toward the crank chamber 32 thereby drawing the refrigerant into the respective compression chamber 102. Furthermore, as the second piston moves from a bottom dead center position toward a valve plate 39, a discharge reed (not shown) is moved to the discharge position thereby forcing the fluid into the discharge chamber 35 through the discharge port 38. In the preferred embodiment, all seven compression chambers 102 include both suction reeds and discharge reeds to control the movement of the fluid within the compressor 10. As appreciated by those skilled in the art, the swash plate 92 is connected to the journal member 82 and slides along the drive shaft 12 in an axial direction, thereby varying inclination of the swash plate 92 with respect to the

longitudinal axis A of the drive shaft 12.

[00036] The journal member 82 is rotated by the drive hub 70 connected to the drive shaft 12 and is rotated with the drive shaft 12 around the longitudinal axis A to permit the swash plate 92 to slide axially and incline with respect to the drive shaft 12. The swash plate 92 converts the rotation of the drive shaft 12 into reciprocation of each piston 100 in the respective compression chamber 102 during the cycle of suction, compression and discharge of the refrigerant is repeated. The refrigerant supplied into the suction chamber 36 is drawn into the compression chamber 102 through the suction port (not shown). After compression, the refrigerant is discharged through the discharge ports 38 into the discharge chamber 35.

[00037] Those skilled in the art will appreciate that when the flow rate of the refrigerant supplied to the crank chamber 32 is decreased, the pressure in the crank chamber 32 is reduced gradually. As a result, the difference between the pressure in the crank chamber 32 and that in the compression chamber 102 during suction stroke decreases. Therefore, the swash plate 92 shifts to the maximum inclination angle position, and the stroke of the pistons 100 increases to increase the displacement. When the flow rate of the refrigerant supplied from the discharge chamber 35 into the crank chamber 32 is increased to exceed the flow rate of the refrigerant flowing into the suction chamber 36, the pressure in the crank chamber 32 is gradually increased. As a result, the difference between the pressure in the crank chamber 32 and the compression chamber 102 during suction stroke increases. This causes the swash plate 92 to shift to the minimum inclination angle position, and the stroke of the piston 100 is reduced, thereby reducing the displacement.

[00038] While the invention has been described with reference to an exemplary embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.